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Salter et al.

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(54) **LUMINESCENT HITCH ANGLE DETECTION COMPONENT**

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(73) Assignee: **Ford Global Technologies, LLC**, Dearborn, MI (US)

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Related U.S. Application Data

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(51) **Int. Cl.**
B60Q 1/00 (2006.01)
B60Q 3/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01B 11/272*** (2013.01); ***B60D 1/00*** (2013.01); ***B60Q 1/22*** (2013.01); ***B60Q 1/305*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B60D 1/00; B60D 1/22; B60D 1/305; B60D 1/36; B60Q 3/06; F21S 48/00; F21S 48/214; F21S 48/215; F21S 48/2212
USPC 362/485, 487, 509–510
See application file for complete search history.

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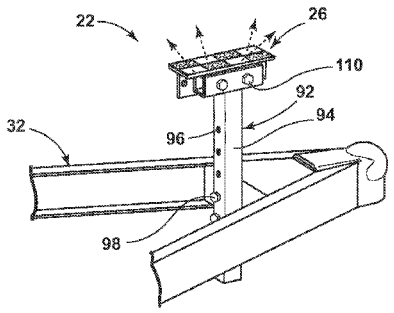
(74) *Attorney, Agent, or Firm* — Vichit Chea; Price Heneveld LLP

(57) **ABSTRACT**

A lighting system for a trailer is provided herein. The lighting system may include a hitch angle detection component disposed on the trailer. A light source is disposed on the vehicle. A photoluminescent structure is disposed on the hitch angle detection component and configured to luminesce in response to excitation by the light source. The hitch angle detection component may further include a predetermined image pattern of a certain size and shape provided on the top surface thereof for capture by an imaging device and recognition by an image processing unit.

20 Claims, 8 Drawing Sheets



(51) **Int. Cl.**

G01B 11/27	(2006.01)
H05B 37/02	(2006.01)
B60D 1/00	(2006.01)
B60Q 1/22	(2006.01)
B60Q 1/30	(2006.01)
F21S 8/10	(2006.01)

(52) **U.S. Cl.**

CPC ***F21S 48/214*** (2013.01); ***H05B 37/0218*** (2013.01); ***H05B 37/0227*** (2013.01); *Y02B 20/46* (2013.01)

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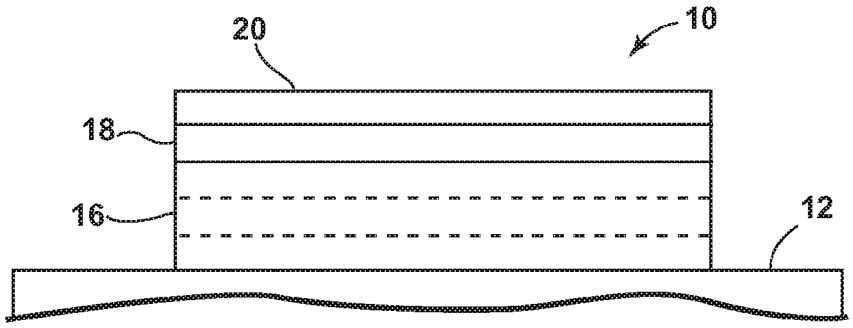


FIG. 1A

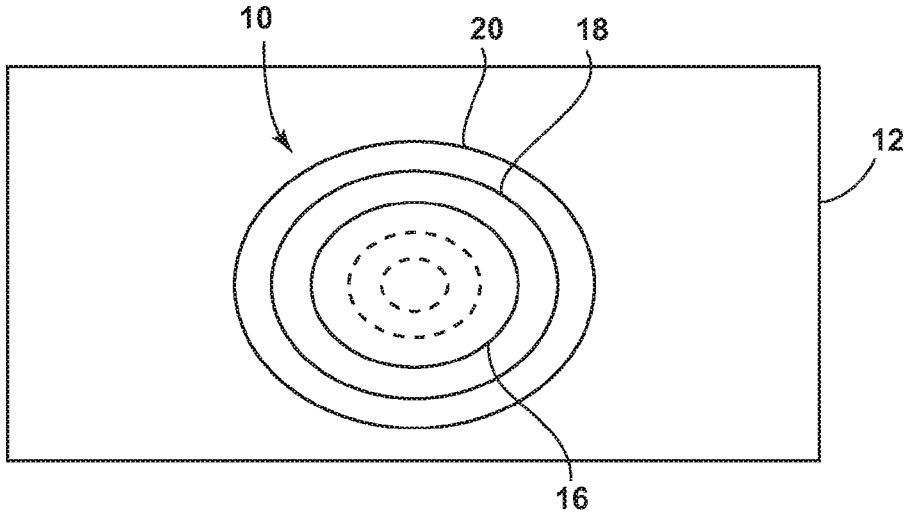


FIG. 1B

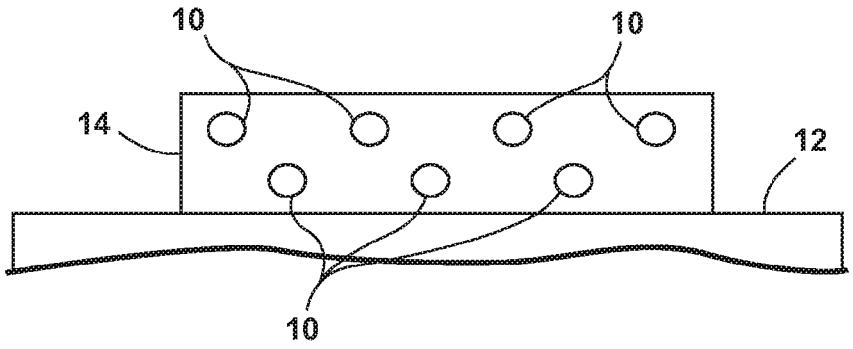


FIG. 1C

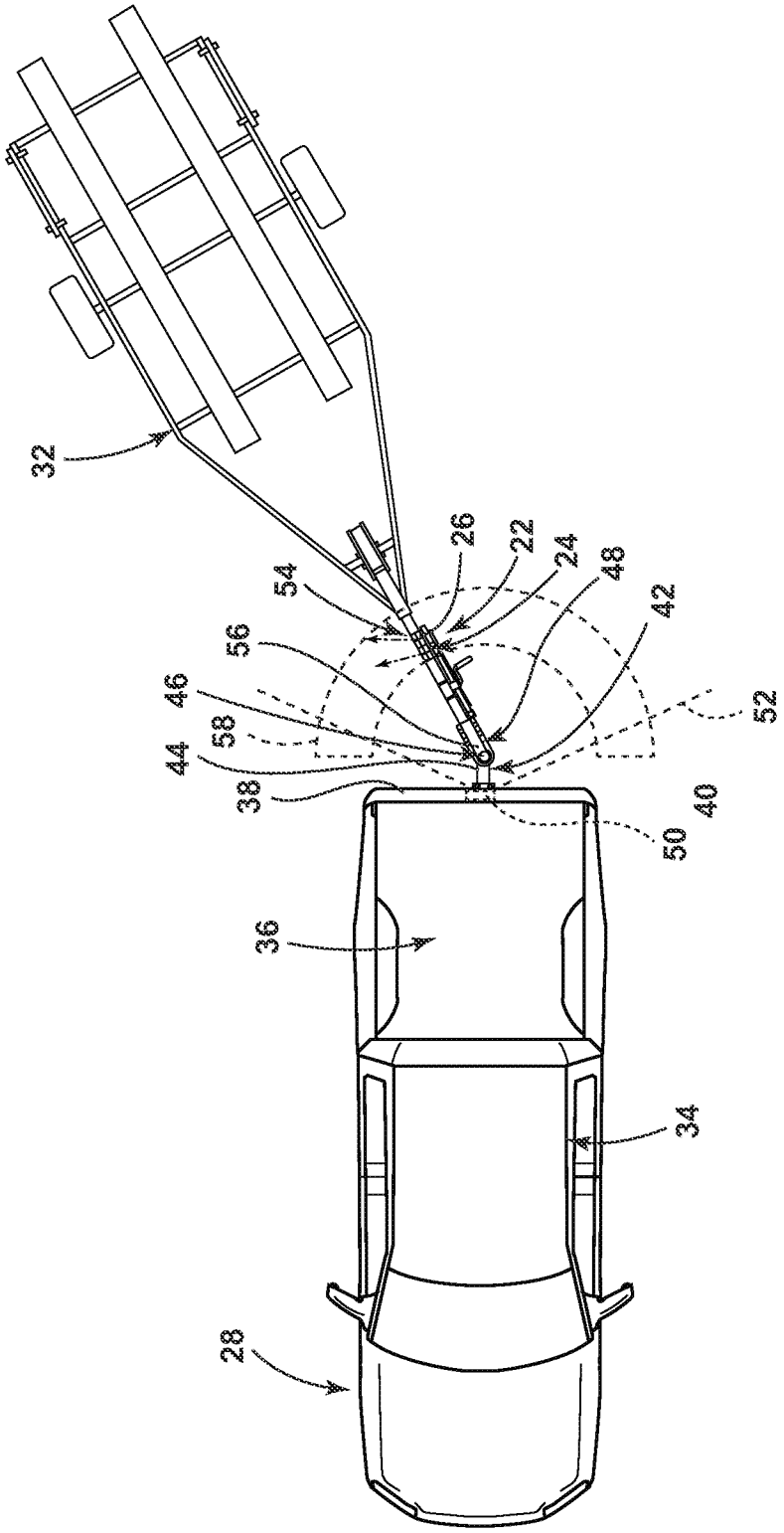
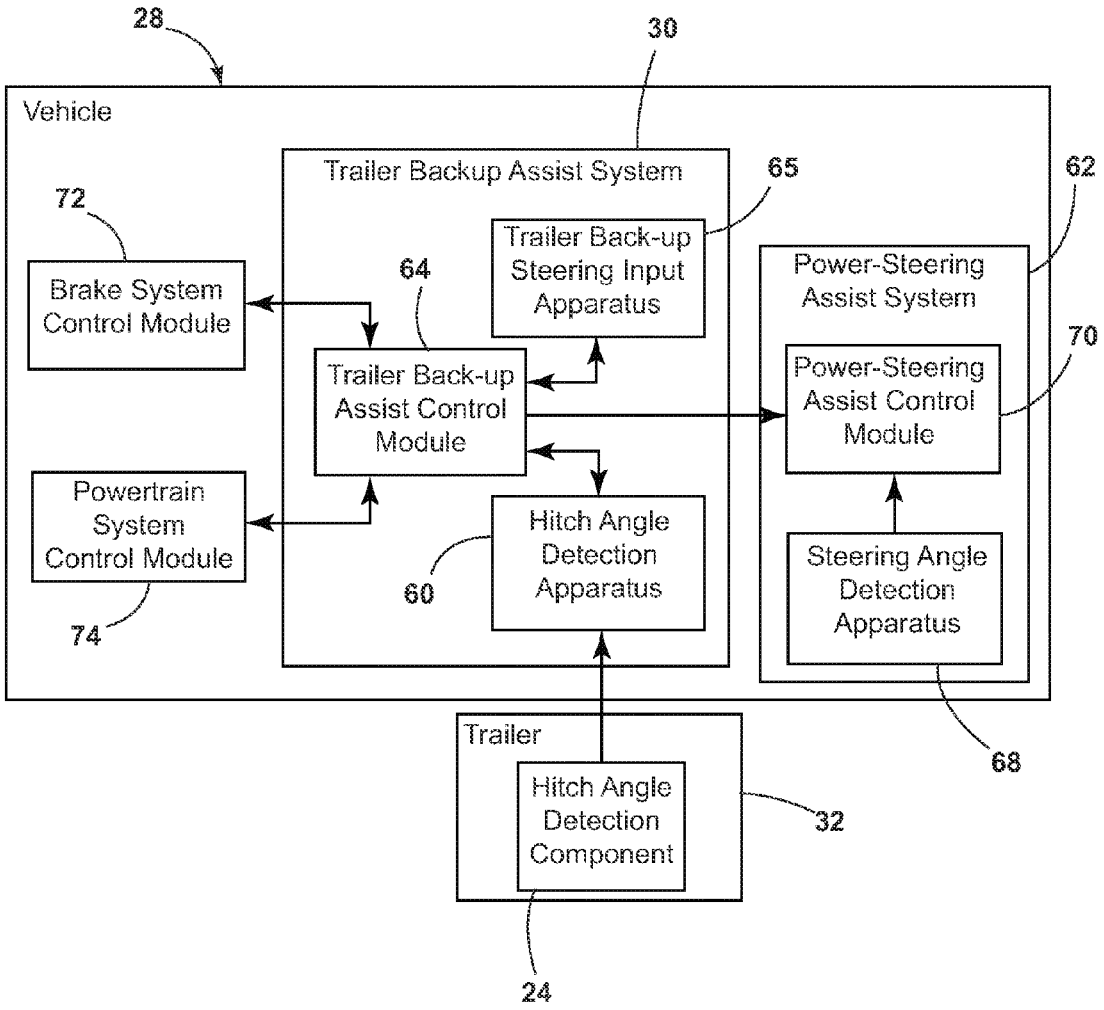


FIG. 2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30
Vehicle
Trailer Backup Assist System
65
62
72
Trailer Back-up Steering Input Apparatus
Power-Steering Assist System
64
Brake System Control Module
Trailer Back-up Assist Control Module
70
Power-Steering Assist Control Module
Powertrain System Control Module
Hitch Angle Detection Apparatus
Steering Angle Detection Apparatus
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74
68
Trailer
Hitch Angle Detection Component
32
24

FIG. 3

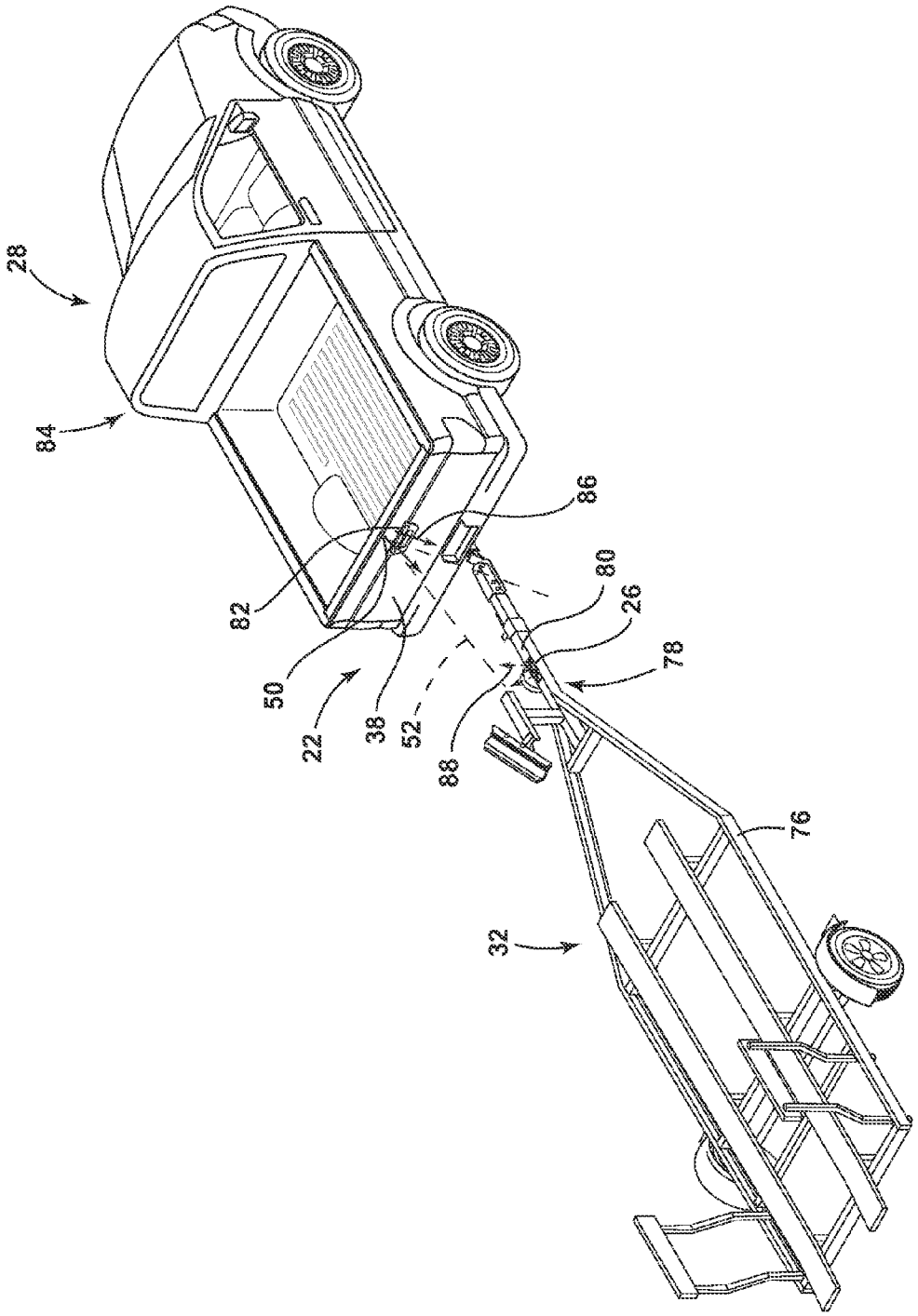
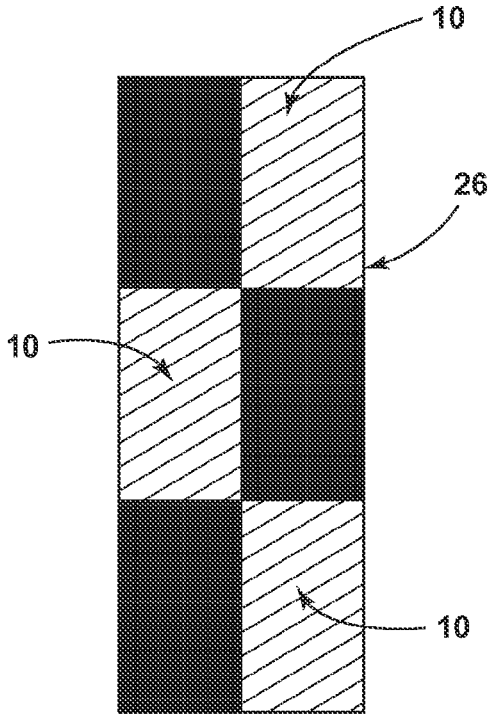


FIG. 4



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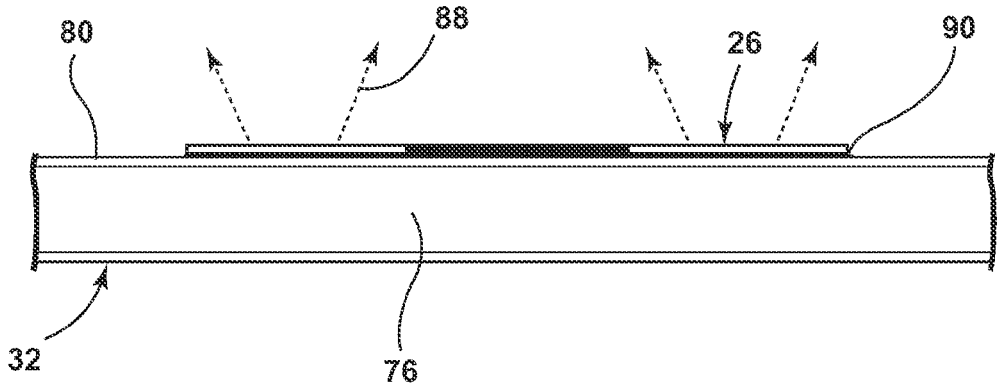

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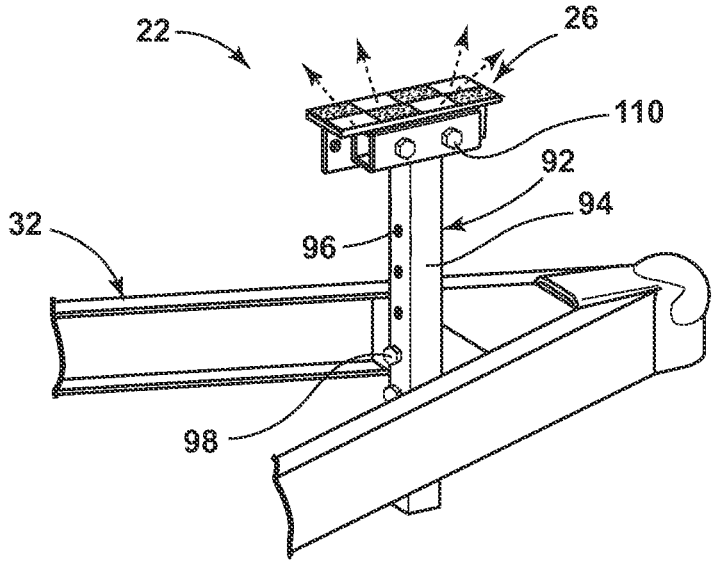
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FIG. 7

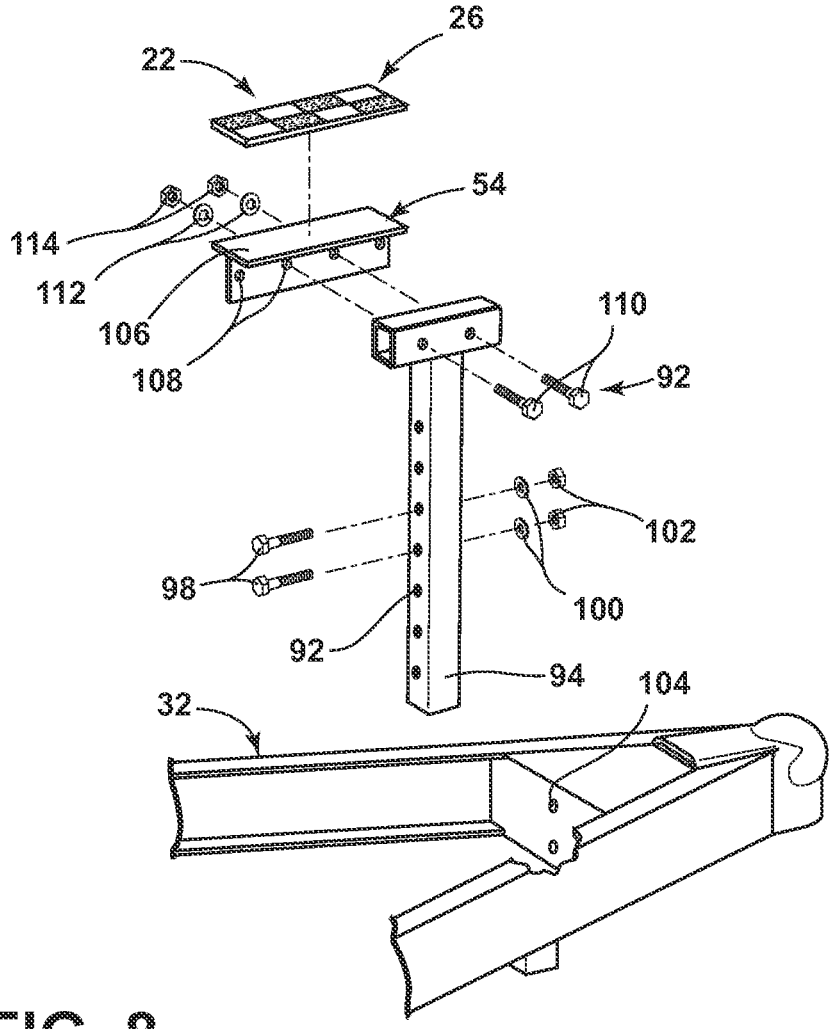
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FIG. 8

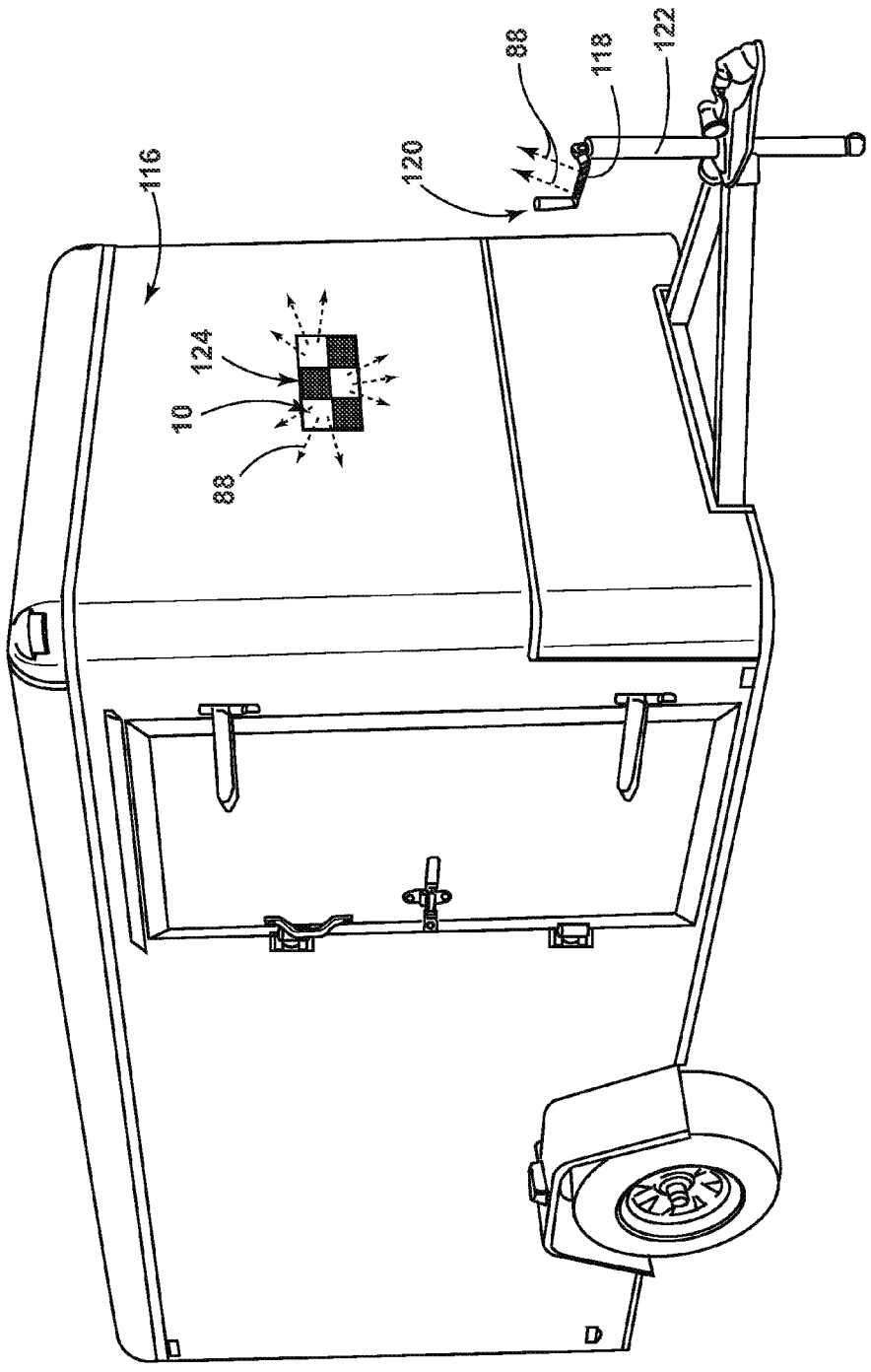
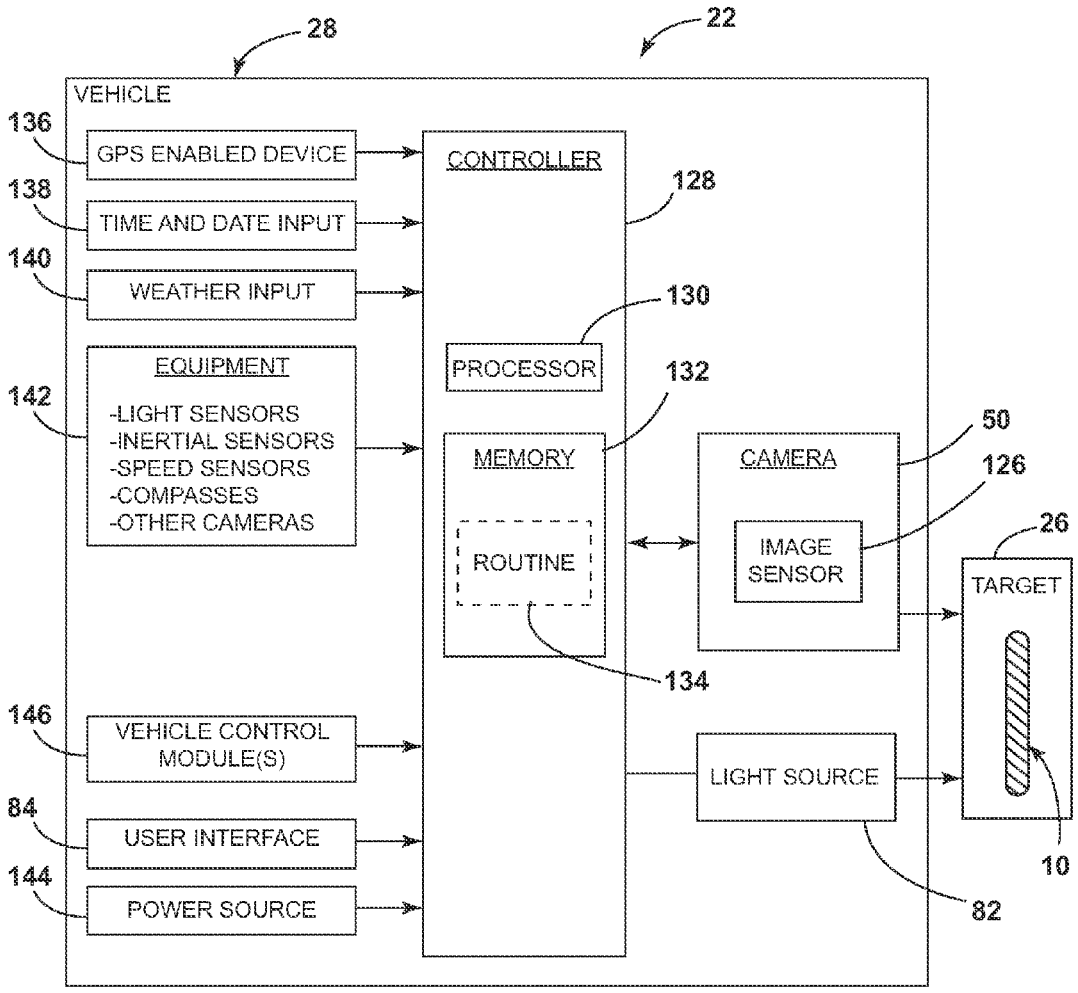


FIG. 9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22
VEHICLE
136
GPS ENABLED DEVICE
138
TIME AND DATE INPUT
140
WEATHER INPUT
142
EQUIPMENT
-LIGHT SENSORS
-INERTIAL SENSORS
-SPEED SENSORS
-COMPASSES
-OTHER CAMERAS
146
VEHICLE CONTROL MODULE(S)
84
USER INTERFACE
144
POWER SOURCE
CONTROLLER
128
130
PROCESSOR
132
MEMORY
ROUTINE
134
CAMERA
50
126
IMAGE SENSOR
LIGHT SOURCE
26
TARGET
10
82

FIG. 10

LUMINESCENT HITCH ANGLE DETECTION COMPONENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 14/603,636, filed Jan. 23, 2015, entitled "DOOR ILLUMINATION AND WARNING SYSTEM" which is a continuation-in-part of U.S. patent application Ser. No. 14/086,442, filed Nov. 21, 2013, entitled "VEHICLE LIGHTING SYSTEM WITH PHOTOLUMINESCENT STRUCTURE." The aforementioned related applications are hereby incorporated by reference as if fully set forth herein.

FIELD OF THE INVENTION

The present disclosure generally relates to vehicle lighting systems, and more particularly, to vehicle lighting systems employing one or more photoluminescent structures.

BACKGROUND OF THE INVENTION

Illumination arising from the use of photoluminescent structures offers a unique and attractive viewing experience. It is therefore desired to implement such structures in automotive vehicles for various lighting applications.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a lighting system for a trailer towed by a vehicle is disclosed. The lighting system includes a hitch angle detection component disposed on the trailer. A light source is disposed on the vehicle. A photoluminescent structure is disposed on the hitch angle detection component and is configured to luminesce in response to excitation by the light source.

According to another aspect of the present invention, a lighting system is disclosed. The lighting system includes a light source. A target assembly having a first luminescent structure thereon is configured to luminesce in response to excitation by at least a portion of the light source.

According to yet another aspect of the present invention, a lighting system for a trailer assembly having a trailer towed by a vehicle is disclosed. The lighting system includes a hitch angle detection component located on the trailer having a predefined pattern thereon. A light source is powered by a vehicle. A photoluminescent structure disposed on the detection component. The photoluminescent structure is configured to luminesce in response to excitation by light output from at least a portion of the light source.

These and other aspects, objects, and features of the present invention will be understood and appreciated by those skilled in the art upon studying the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1**A is a side view of a photoluminescent structure rendered as a coating for use in a luminescent seatbelt assembly according to one embodiment;

FIG. **1**B is a top view of a photoluminescent structure rendered as a discrete particle according to one embodiment;

FIG. **1**C is a side view a plurality photoluminescent structures rendered as discrete particles and incorporated into a separate structure;

FIG. **2** is a top plan view of a trailer attached to a vehicle equipped with a lighting system employed on a hitch angle detection component, according to one embodiment;

FIG. **3** is a vehicle-trailer combination, the vehicle being configured to perform a trailer backup assist function in accordance with an embodiment;

FIG. **4** is a schematic diagram illustrating the lighting system being implemented in the vehicle, wherein the tow vehicle is attached to a trailer and features a trailer backup assist system employing vision based target detection;

FIG. **5** is a top plan view of a target assembly having photoluminescent structures disposed thereon, according to one embodiment;

FIG. **6** is an exemplary side view of the target assembly adhered to a portion of the trailer;

FIG. **7** is a schematic view of a front portion of the trailer having a target mounting system assembled thereto, according to one embodiment;

FIG. **8** is an exploded view of the target mounting system and trailer shown in FIG. **7**;

FIG. **9** is an exemplary perspective view of the lighting system employed on a vertical portion of an enclosed trailer; and

FIG. **10** is a block diagram of the vehicle and the lighting system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizontal," and derivatives thereof shall relate to the invention as oriented in FIG. **2**. However, it is to be understood that the invention may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

As required, detailed embodiments of the present invention are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to a detailed design and some schematics may be exaggerated or minimized to show function overview. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

As used herein, the term "and/or," when used in a list of two or more items, means that any one of the listed items can be employed by itself, or any combination of two or more of the listed items can be employed. For example, if a composition is described as containing components A, B, and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination; B and C in combination; or A, B, and C in combination.

The following disclosure describes a lighting system configured as a hitch angle detection component that coop-

erates with a vehicle to illuminate an area and/or in a pre-defined pattern for recognition by the vehicle. The lighting system may advantageously employ one or more photoluminescent structures to illuminate in response to pre-defined events. The one or more photoluminescent structures may be configured to convert light received from an associated light source and re-emit the light at a different wavelength typically found in the visible spectrum.

The lighting system may be configured to cooperate with a vehicle implementing trailer backup assist functionality. In particular, such trailer backup assist functionality provides for controlling curvature of a path of travel of a trailer attached to a vehicle (i.e., trailer path curvature control) by allowing a driver of the vehicle to specify a desired path of the trailer by inputting a desired trailer path curvature as the backup maneuver of the vehicle and trailer progresses. The trailer backup assist system may automatically steer the vehicle-trailer combination as a driver uses the vehicle transmission, accelerator, and brake to reverse the vehicle-trailer combination.

Trailer backup assist functionality is directed to implementing one or more countermeasures for limiting the potential of a jackknife condition being attained between a vehicle and a trailer being towed by the vehicle while backing up. In certain embodiments, curvature of a path of travel of the trailer (i.e., trailer path curvature control) can be controlled by allowing a driver of the vehicle to specify a desired path of the trailer by inputting a desired trailer path curvature as the backup maneuver of the vehicle and trailer progresses.

Referring to FIGS. **1**A-**1**C, various exemplary embodiments of photoluminescent structures **10** are shown, each capable of being coupled to a substrate **12**, which may correspond to a vehicle fixture or vehicle related piece of equipment. In FIG. **1**A, the photoluminescent structure **10** is generally shown rendered as a coating (e.g., a film) that may be applied to a surface of the substrate **12**. In FIG. **1**B, the photoluminescent structure **10** is generally shown as a discrete particle capable of being integrated with a substrate **12**. In FIG. **1**C, the photoluminescent structure **10** is generally shown as a plurality of discrete particles that may be incorporated into a support medium **14** (e.g., a film) that may then be applied (as shown) or integrated with the substrate **12**.

At the most basic level, a given photoluminescent structure **10** includes an energy conversion layer **16** that may include one or more sub layers, which are exemplarily shown through broken lines in FIGS. **1**A and **1**B. Each sub layer of the energy conversion layer **16** may include one or more photoluminescent materials having energy converting elements with phosphorescent or fluorescent properties. Each photoluminescent material may become excited upon receiving light of a specific wavelength, thereby causing the light to undergo a conversion process. Under the principle of down conversion, the inputted light is converted into a longer wavelength light that is outputted from the photoluminescent structure **10**. Conversely, under the principle of up conversion, the inputted light is converted into a shorter wavelength light that is outputted from the photoluminescent structure **10**. When multiple distinct wavelengths of light are outputted from the photoluminescent structure **10** at the same time, the wavelengths of light may mix together and be expressed as a multicolor light.

In some embodiments, light that has been down converted or up converted may be used to excite other photoluminescent material(s) found in the energy conversion layer **16**. The process of using converted light outputted from one photoluminescent material to excite another, and so on, is generally known as an energy cascade and may serve as an alternative for achieving various color expressions. With respect to either conversion principle, the difference in wavelength between the exciting light and the converted light is known as the Stokes shift and serves as the principle driving mechanism for an energy conversion process corresponding to a change in wavelength of light. In the various implementations discussed herein, each of the photoluminescent structures may operate under either conversion principle.

The energy conversion layer **16** may be prepared by dispersing the photoluminescent material in a polymer matrix to form a homogenous mixture using a variety of methods. Such methods may include preparing the energy conversion layer **16** from a formulation in a liquid carrier medium and coating the energy conversion layer **16** to a desired substrate. The energy conversion layer **16** may be applied to a substrate by painting, screen printing, spraying, slot coating, dip coating, roller coating, and bar coating. Alternatively, the energy conversion layer **16** may be prepared by methods that do not use a liquid carrier medium. For example, the energy conversion layer **16** may be rendered by dispersing the photoluminescent material into a solid state solution (homogenous mixture in a dry state) that may be incorporated in a polymer matrix, which may be formed by extrusion, injection molding, compression molding, calendaring, thermoforming, etc. The energy conversion layer **16** may then be integrated into a substrate using any methods known to those skilled in the art. When the energy conversion layer **16** includes sub layers, each sub layer may be sequentially coated to form the energy conversion layer **16**. Alternatively, the sub layers can be separately prepared and later laminated or embossed together to form the energy conversion layer **16**. Alternatively still, the energy conversion layer **16** may be formed by coextruding the sub layers.

Referring back to FIGS. **1**A and **1**B, the photoluminescent structure **10** may optionally include at least one stability layer **18** to protect the photoluminescent material contained within the energy conversion layer **16** from photolytic and thermal degradation. The stability layer **18** may be configured as a separate layer optically coupled and adhered to the energy conversion layer **16**. Alternatively, the stability layer **18** may be integrated with the energy conversion layer **16**. The photoluminescent structure **10** may also optionally include a protection layer **20** optically coupled and adhered to the stability layer **18** or other layer (e.g., the conversion layer **16** in the absence of the stability layer **18**) to protect the photoluminescent structure **10** from physical and chemical damage arising from environmental exposure. The stability layer **18** and/or the protective layer **20** may be combined with the energy conversion layer **16** through sequential coating or printing of each layer, sequential lamination or embossing, or any other suitable means.

Additional information regarding the construction of photoluminescent structures **10** is disclosed in U.S. Pat. No. 8,232,533 to Kingsley et al., entitled "PHOTOLYTICALLY AND ENVIRONMENTALLY STABLE MULTILAYER STRUCTURE FOR HIGH EFFICIENCY ELECTROMAGNETIC ENERGY CONVERSION AND SUSTAINED SECONDARY EMISSION," filed Nov. 8, 2011, the entire disclosure of which is incorporated herein by reference. For additional information regarding fabrication and utilization of photoluminescent materials to achieve various light emissions, refer to U.S. Pat. No. 8,207,511 to Bortz et al., entitled "PHOTOLUMINESCENT FIBERS, COMPOSITIONS AND FABRICS MADE THEREFROM," filed Jun. 5, 2009;

U.S. Pat. No. 8,247,761 to Agrawal et al., entitled "PHOTOLUMINESCENT MARKINGS WITH FUNCTIONAL OVERLAYERS," filed Oct. 19, 2011; U.S. Pat. No. 8,519,359 B2 to Kingsley et al., entitled "PHOTOLYTICALLY AND ENVIRONMENTALLY STABLE MULTILAYER STRUCTURE FOR HIGH EFFICIENCY ELECTROMAGNETIC ENERGY CONVERSION AND SUSTAINED SECONDARY EMISSION," filed Mar. 4, 2013; U.S. Pat. No. 8,664,624 B2 to Kingsley et al., entitled "ILLUMINATION DELIVERY SYSTEM FOR GENERATING SUSTAINED SECONDARY EMISSION," filed Nov. 14, 2012; U.S. Patent Publication No. 2012/0183677 to Agrawal et al., entitled "PHOTOLUMINESCENT COMPOSITIONS, METHODS OF MANUFACTURE AND NOVEL USES," filed Mar. 29, 2012; U.S. Patent Publication No. 2014/0065442 A1 to Kingsley et al., entitled "PHOTOLUMINESCENT OBJECTS," filed Oct. 23, 2012; and U.S. Patent Publication No. 2014/0103258 A1 to Agrawal et al., entitled "CHROMIC LUMINESCENT COMPOSITIONS AND TEXTILES," filed Dec. 19, 2013, all of which are incorporated herein by reference in their entirety.

Referring now to FIG. **2**, a lighting system **22** includes a hitch angle detection component **24**, such as an image identification feature that may be configured as a trailer target assembly **26** that cooperates with a vehicle **28** to illuminate an area and/or in a pre-defined pattern, according to one embodiment. The vehicle **28** illustrated is shown towing a trailer **32**. The target assembly **26** may be used for a plurality of functions, such as assisting a trailer backup assist system **30** (FIG. **3**). Additionally, or alternatively, the target assembly **26** may be utilized for monitoring the trailer **32** while the trailer is towed by the vehicle **28** in a forward or rearward direction. Exemplary functions include, but are not limited to, trailer sway monitoring, tire pressure monitoring, or any other desired function that may be sensed by the vehicle **28**. The vehicle **28** is in the form of a pick-up truck having a cab **34** and a truck bed **36**. A pivotable tailgate **38** is coupled to a rear portion **40** of the truck bed **36**.

The vehicle **28** further includes a vehicle hitch connector **42** in the form of a receiver hitch **44** and ball **46**. The trailer **32** has a trailer hitch connector **48** in the form of a coupler assembly **56** that may be connected to the vehicle hitch **44**. The coupler assembly **56** latches onto the hitch ball **46** to provide a pivoting ball joint. The vehicle **28** is equipped with a video imaging device (e.g., a camera) **50** located in the vehicle tailgate **38** at the rear portion **40** of the vehicle **28**. The video imaging camera **50** has an imaging field of view **52** and is located and oriented to capture one or more images of the trailer **32** including a region containing one or more desired target placement zone(s) **54**. It should be appreciated that one or more cameras **50** may be located at other locations on the vehicle **28** to acquire images of the trailer **32** and the target placement zone(s) **54**. The imaging field of the camera **50** may be configured to view a target-working envelope **58** that is defined by the full range of possible angles between the trailer **32** and vehicle **28** while the trailer **32** is coupled to the vehicle **28**. For example, according to one embodiment, the trailer **32** may be disposed in a range of −90 degrees to 90 degrees from an axis extending through the longitudinal centerline of the vehicle **28**.

In order to utilize a target assembly **26** on a trailer **32** that is not currently equipped with a suitable pre-existing target assembly **26**, a user may place the target assembly **26** onto the trailer **32** within a desired target placement zone **54** so that the camera **50** may capture one or more images of the target assembly **26** to determine trailer related information for the trailer backup assist system **30**, such as hitch angle information for the hitch angle detection apparatus **60** (FIG. **3**). It should be appreciated that the lighting system **22** described herein may be utilized for any vehicle **28** such as, but not limited to, coupes, sedans, trucks, sport utility, vans, and the like and may cooperate with any type of towable assembly that may be coupled to the vehicle **28**. Further, it should be appreciated that any lighting system **22** found elsewhere on the vehicle **28** may also be manufactured in accordance with the principles of the present disclosure.

Referring to FIG. **3**, an embodiment of a vehicle **28** configured for performing trailer backup assist functionality is shown. A trailer backup assist system **30** of the vehicle **28** controls the curvature of path of travel of a trailer **32** that is towed by the vehicle **28**. Such control is accomplished through interaction of a power-steering assist system **62** of the vehicle **28** and the trailer backup assist system **30**.

The trailer backup assist system **30**, according to one embodiment, includes a trailer backup assist control module **64**, a trailer backup steering input apparatus **66**, and a hitch angle detection apparatus **60**. The trailer backup assist control module **64** is connected to the trailer backup steering input apparatus **65** and the hitch angle detection apparatus **60** for allowing communication of information therebetween. The trailer backup steering input apparatus **66** may be coupled to the trailer backup assist control module **64** in a wired or wireless manner. The trailer backup assist system control module **64** is attached to a power-steering assist control module **70** of the power-steering assist system **62** for allowing information to be communicated therebetween. A steering angle detection apparatus **68** of the power-steering assist system **62** is connected to the power-steering assist control module **70** for providing information thereto. The trailer backup assist system **30** is also attached to a brake system control module **72** and a powertrain system control module **74** for allowing communication of information therebetween. Jointly, the trailer backup assist system **30**, the power-steering assist system **62**, the brake system control module **72**, the powertrain system control module **74**, and a gear selection device (PRNDL), define a trailer backup assist architecture configured in accordance with an embodiment.

The trailer backup assist control module **64** is configured for implementing logic (i.e., instructions) for receiving information from the trailer backup steering input apparatus **66**, the hitch angle detection apparatus **60**, the power-steering assist control module **70**, the brake system control module **72**, and the powertrain system control module **74**. The trailer backup assist control module **64** (e.g., a trailer curvature algorithm thereof) generates vehicle **28** steering information as a function of all or a portion of the information received from the trailer backup steering input apparatus **66**, the hitch angle detection apparatus **60**, the power-steering assist control module **70**, the brake system control module **72**, and/or the powertrain system control module **74**. Thereafter, the vehicle **28** steering information is provided to the power-steering assist control module **70** for affecting steering of the vehicle **28** by the power-steering assist system **62** to achieve a commanded path of travel for the trailer **32**.

The trailer backup steering input apparatus **66** provides the trailer backup assist control module **64** with information defining the commanded path of travel of the trailer **32** to the trailer backup assist control module **64** (i.e., trailer steering information). The trailer steering information can include information relating to a commanded change in the path of travel (e.g., a change in radius of path curvature) and information relating to an indication that the trailer **32** is to

travel along a path defined by a longitudinal centerline axis of the trailer **32** (i.e., along a substantially straight path of travel).

The hitch angle detection apparatus **60**, which operates in conjunction with the hitch angle detection component **24** of the trailer **32**, provides the trailer backup assist control module **64** with information relating to an angle between the vehicle **28** and the trailer **32** (i.e., hitch angle information). In one embodiment, the hitch angle detection apparatus **60** is a camera-based apparatus such as, for example, an existing rear view camera **50** of the vehicle **28** that images (i.e., visually monitors) the target assembly **26** (i.e., the hitch angle detection component **24**) attached the trailer **32** as the trailer **32** is being backed by the vehicle **28**. The hitch angle detection component **24** may be a dedicated component (e.g., an item attached to/integral with a surface of the trailer **32** for the express purpose of being recognized by the hitch angle detection apparatus **60**). The hitch angle detection apparatus **60** can be configured for detecting a jackknife enabling condition and/or related information (e.g., when a hitch angle threshold has been met).

The power-steering assist control module **70** provides the trailer backup assist control module **64** with information relating to a rotational position (e.g., angle) of the steering wheel angle and/or a rotational position (e.g., turning angle (s)) of steered wheels of the vehicle **28**. In some embodiments, the trailer backup assist control module **64** can be an integrated component of the power-steering assist system **62**. For example, the power-steering assist control module **70** can include a trailer backup assist algorithm for generating vehicle **28** steering information as a function of all or a portion of information received from the trailer backup steering input apparatus **66**, the hitch angle detection apparatus **60**, the power-steering assist control module **70**, the brake system control module **72**, and the powertrain system control module **74**.

The brake system control module **72** provides the trailer backup assist control module **64** with information relating to vehicle speed. Such vehicle speed information can be determined from individual wheel speeds as monitored by the brake system control module **72** or may be provided by an engine control module with signal plausibility. Vehicle speed may also be determined from an engine control module. In some instances, individual wheel speeds can also be used to determine a vehicle **28** yaw rate and such yaw rate can be provided to the trailer backup assist control module **64** for use in determining the vehicle **28** steering information. In certain embodiments, the trailer backup assist control module **64** can provide vehicle **28** braking information to the brake system control module **72** for allowing the trailer backup assist control module **64** to control braking of the vehicle **28** during backing of the trailer **32**. For example, using the trailer backup assist control module **64** to regulate speed of the vehicle **28** during backing of the trailer **32** can reduce the potential for unacceptable trailer backup conditions. Examples of unacceptable trailer backup conditions include, but are not limited to, a vehicle over speed condition, a high hitch angle rate, trailer **32** angle dynamic instability, a calculated theoretical trailer **32** jackknife condition (defined by a maximum vehicle **28** steering angle, drawbar length, tow vehicle **28** wheelbase and an effective trailer **32** length), or physical contact jackknife limitation (defined by an angular displacement limit relative to the vehicle **28** and the trailer **32**), and the like.

The powertrain system control module **74** interacts with the trailer backup assist control module **64** for regulating speed and acceleration of the vehicle **28** during backing of the trailer **32**. Regulation of the speed of the vehicle **28** is necessary to limit the potential for unacceptable trailer backup conditions such as, for example, jackknifing and trailer angle dynamic instability.

Referring to FIGS. **4-6**, a trailer **32** is shown coupled to a vehicle **28**. The trailer **32** includes a frame **76** including a longitudinally extending bar or trailer tongue **78**. A top horizontal surface **80** of trailer tongue **78** is shown providing a target placement zone **54** for receiving the target assembly **26**. It should be appreciated that the trailer **32** may be configured in various shapes and sizes and may offer one or more other suitable target placement zones **54** for receiving the target assembly **26**. The target placement zone **54** defines at least one desired location for placement of the target assembly **26**.

As previously described, the trailer backup assist system **30** may employ a vision based target detection system, wherein the hitch angle detection component **24** is an identifiable visual target located on a trailer **32** attached to a towing vehicle **28**. The towing vehicle **28** may be equipped with a rear view camera **50**, which functions as the hitch angle detecting apparatus, and is configured to image the target assembly **26** and process acquired image data to generate trailer related information used in a variety of applications associated with the trailer backup assist system **30**. Nevertheless, there may be some circumstances that hinder target detection accuracy.

Accordingly, a light source **82** may be disposed on and/or within a portion of the vehicle **28**, such as the tailgate **38**. The light source **82** may comprise any form of light source. For example fluorescent lighting, light emitting diodes (LEDs), organic LEDs (OLEDs), polymer LEDs (PLEDs), solid state lighting, or any other form of lighting configured to emit light may be utilized. As illustrated in FIG. **4**, the light source **82** is disposed on the tailgate **38** and is oriented to emit inputted light **86** rearwardly towards the target assembly **26**. The light source **82** may be an independent light source **82** configured for utilization during the illumination of a target assembly **26** or, alternatively, may be used for a plurality of functions, such as, but not limited to, as a device for illuminating an area rearward of the vehicle **28**, a feature on the tailgate of the vehicle **28**, or the license plate on the vehicle **28**. Alternatively still, the light source **82** may be disposed in a vehicle **28** light assembly and may simultaneously be utilized as an illumination source for the target assembly **26** and as a backup light, a running light, or a brake light.

Additionally, the light source **82** may include optics configured to disperse or focus inputted light **86** being emitted therefrom to further illuminate the target assembly **26**. For example, optics may be utilized for directing a first portion of inputted light **86** emitted from the light source **82** towards the target assembly **26**. A second portion of inputted light **86** emitted from the light source **82** may be directed towards a feature on the rearward of the vehicle **28** or on the trailer **32**. It should be appreciated that the light source **82** may be located on any surface.

In operation, the light source **82** may be activated using a variety of means. For example, the lighting system **22** may include a user interface **84** on and/or within the vehicle **28**. The user interface **84** may be configured such that a user may control the wavelength of inputted light **86** that is emitted by the light source **82** and/or the portions of the light source **82** that are illuminated. Alternatively, the user interface **84** may be used to switch the lighting system **22** through a plurality of modes and/or functions. The user interface **84** may use any type of control known in the art for control the

light source **82**, such as, but not limited to, switches (e.g., proximity sensors, push-type buttons) and may be disposed in any practicable location. Additionally, or alternatively, the light source **82** may be automatically activated via an onboard vehicle system such as the trailer backup assist system **30** and/or other vehicle system. For instance, when performing a backup maneuver, the trailer backup assist system **30** may activate the light source **82**. It is contemplated that the lighting system **22** may have a wide range of target assembly **26** locations such that the lighting system **22** may be used for a plurality of functions. Exemplary functions include usage as a target, ambient lighting, and/or a lamp that provides illumination to an area proximate the trailer hitch connector **48**.

According to one embodiment, the light source **82** includes a flexible circuit board (e.g., a copper flexible circuit) that is coupled to, attached to, or disposed on the vehicle **28**. In such an arrangement, the flexible circuit board may flex in conjunction with the body of the vehicle **28** to allow the lighting system **22** to be contoured with any desired style and/or a plurality of target placement zones **54**. Alternatively, the light source **82** may be mounted within the body panel and emit inputted light **86** through a portion thereof toward the target working envelope **58**.

A photoluminescent structure **10** containing at least one photoluminescent material is configured to illuminate in response to inputted light **86** emitted from the light source **82**. More specifically, inputted light **86** emitted from the light source **82** towards the target assembly **26** may be converted by the photoluminescent structure **10** and re-emitted as outputted light **88** having a different wavelength, typically in the visible spectrum. According to the illustrated embodiment, the target assembly **26** location is an area disposed proximate to the vehicle **28**.

More specifically, the photoluminescent material is formulated to have an absorption spectrum that includes the emission wavelength of the inputted light **86** supplied from the light source **82**. The photoluminescent material is also formulated to have a Stokes shift resulting in the converted visible light **88** having an emission spectrum expressed in a desired color, which may vary per lighting application. The converted visible light **88** is outputted from the light source **82** via the viewable portion **124**, thereby causing the viewable portion **124** to illuminate in the desired color. In one embodiment, the energy conversion process is undertaken by way of down conversion, whereby the inputted light **86** includes light on the lower end of the visibility spectrum such as blue, violet, or ultraviolet (UV) light. Doing so enables blue, violet, or UV LEDs to be used as the light source **82**, which may offer a relative cost advantage over simply using LEDs of the desired color and foregoing the energy conversion, process altogether. Moreover, it is contemplated that blue LEDs may be utilized, which may run at a much higher intensity to compensate for dirt, snow, rain, etc. than white LEDs. Also, the utilization of blue LEDs may reduce rearward glare due to relative insensitivity of human eye to blue light so that the target assembly **26** may brilliantly illuminate. Furthermore, the illumination provided by the viewable portion **124** may offer a unique, substantially uniform, and/or attractive viewing experience that may be difficult to duplicate through non-photoluminescent means.

Inputted light **86** emitted from the light source **82** may be converted by the photoluminescent structure **10** and re-emitted as outputted light **88** having a different wavelength, typically in the visible spectrum. Such a configuration may assist a trailer backup assist system **30** by creating a more visible target assembly **26** in low lighting conditions and through the plurality of orientations between the trailer **32** and vehicle **28** as the target assembly **26** is actively illuminated with a diffused, non-glared light. Such a configuration may be desirable for the camera **50** because the target assembly **26** may emit outputted light **88** rather than reflecting light off the target assembly **26** for the camera **50**.

As described above, the photoluminescent structure **10** may convert the inputted light **86** emitted from the light source **82** from a first wavelength to a second wavelength. Accordingly, the target assembly **26** may illuminate, rather than reflect light from a light source **82** on a vehicle **28** thereby making the target assembly **26** much more visible to the camera **50**. Additionally, the photoluminescent structure **10** may also substantially uniformly diffuse outputted light **88** from the target. In one embodiment, the energy conversion process is undertaken by way of down conversion, whereby the inputted light **86** includes light on the lower end of the visibility spectrum such as blue, violet, or ultraviolet (UV) light. Doing so enables blue, violet, or UV LEDs to be used, which may offer a relative cost advantage over simply using LEDs of the desired color. Furthermore, the illumination provided may offer a unique, substantially uniform, and/or attractive viewing experience that may be difficult to duplicate through non-photoluminescent means. Alternatively, a white LED with a high blue content may be used such that the light source **82** may illuminate an area behind the vehicle **28** and/or excite the photoluminescent structure **10**.

According to one embodiment, the trailer backup system **30** may monitor the target assembly **26** while the vehicle **28** is moving in a forward direction through the utilization of blue LEDs. Under the Federal Motor Vehicle Safety Standards, white light emittance while the vehicle **28** is moving in a forward direction is prohibited. However, inputted light **86** having a wavelength that may be in the non-visible spectrum may be utilized during operation and may provide illumination of the target assembly **26** during operation. For example, the camera **50** may monitor the target assembly **26** during forward movement and be configured to alert an occupant of the vehicle **28** if the target assembly **26** changes orientation, which may be an indication of an issue with the trailer **32**.

As shown in FIGS. **5** and **6**, the target assembly **26** may include an adhesive **90** on the bottom surface and a predetermined image pattern of a certain size and shape provided on the top surface for capture by the video camera **50** and recognition by the image processing. The target assembly **26** may have a rectangular shape, according to one embodiment, and may have a camera image recognizable pattern such as the checker pattern shown. The image processing may include known image pattern recognition routines **134** (FIG. **10**) for identifying a target pattern and its location on a trailer **32**. However, it should be appreciated that other target assembly **26** shapes, sizes, and patterns may be employed. It should further be appreciated that the target assembly **26** may otherwise be connected to the trailer **32** using connectors, such as fasteners, which may connect to the trailer **32** or to an attachment to the trailer **32**. It should further be appreciated that the target assembly **26** can be attached via magnet, glued on, painted on, or any number of other suitable means.

According to one embodiment, the target assembly **26** is a molded component and an overmold material **66** is disposed thereover. To form the target assembly **26**, a single or plurality of polymers may be utilized. Further, according to one embodiment, the target assembly **26** may be fabricated

from molding techniques such as dual injection molding, two-shot molding, two-color molding, two-component molding, and/or multi-shot molding.

In embodiments where the overmold material **66** is cured under pressure, the overmold material **66** may be applied to the target assembly **26** in a partly cured condition. In one embodiment, the over molding process includes applying the overmold material **66** onto at least a part of the target assembly **26** by spraying, brushing, dipping, printing, laminating or rolling, followed by curing the overmold material **66**. In some embodiments, the overmold material **66** may include a polymeric material, silicon, urethane material, vinyl, and/or any other material that may be advantageous or structurally sound for placement within a zone that is regularly contacted and prone to environmental debris. Moreover, in some embodiments, the overmold material **66** may be transparent or translucent and may provide light diffusing and/or anti-glare characteristics. It should be appreciated that the overmold material **66** may be disposed over any and/or all components of the lighting system **22** such that the overmold material **66** may encapsulate all of the components into a single piece that may be applied, attached, or otherwise coupled to the desired target zone **54**.

Although the lighting system **22** has been described herein as being featured in a tow vehicle **28** generally embodied as a pickup truck, it should be appreciated that the lighting system **22** may be featured in other tow and non-tow vehicles **28** alike, which may include, but are not limited to, buses, sports utility vehicles, vans, station wagons, sedans, and coupes. Furthermore, while the lighting system **22** is intended for use with the trailer backup assist system **30**, it should be appreciated that the vehicle lighting system **22** may additionally, or alternatively, be adapted for use with other vehicle related applications. For example, the additional lighting provided by the lighting system **22** may enable a vehicle **28** equipped with a rear view camera **50** system to render clearer images on a display screen when it's dark outside. This may prove especially useful when performing a backup maneuver in low visibility situations. At the most basic level, the lighting system **22** may simply be used as a utility light. For example, the lighting system **22** may be activated to aid an operator with attaching/detaching a trailer **32** to/from a tow vehicle **28** in low light conditions.

Referring to FIGS. **7-8**, a target assembly **26** location may be added to a given trailer **32** by use of a target mounting system **92**, according to one embodiment. The target mounting system **92** is shown installed onto the trailer **32** to present a target assembly **26** that is viewable by the camera **50** within a desired target placement zone **54**. The target mounting system **92** includes a vertical mounting bracket **94** having a plurality of bolt receiver holes **96** extending vertically to allow for a desired vertical height adjustment. The bracket **94** may be assembled onto the trailer **32** via holes using bolts **98**, washers **100**, and nuts **102**. The height of the bracket **94** may be adjusted depending on which holes are aligned with the trailer holes **104**. Mounted to the top of the bracket **94** is a target plate **106** having a top target placement zone **54** onto which the target assembly **26** is located. The plate **106** likewise has a plurality of holes **108** that align horizontally with the holes in the bracket **94** and may be assembled thereto via bolts **110**, washers **112**, and nuts **114**. Accordingly, the plate **106** may be adjusted both vertically and horizontally to a desired position so as place the target assembly **26** adjustably within a desired location so that the target assembly **26** is easily acquired by the camera **50** and processed by the image processing.

As shown in FIG. **9**, the target assembly **26** is configured to attach to a forwardly, vertical surface **116** of an enclosed trailer **32**. As illustrated, a second photoluminescent structure **118** is disposed on a feature **120** of the trailer **32**, such as a portion of a jack **122** coupled to the trailer **32**. As described above, the light source **82** emits inputted light **86** towards the photoluminescent structures **10**, **118**, which converts the inputted light **86** to outputted light **88** of a different wavelength. The outputted light **88** may be used as welcome/farewell sequence light, ambient light, illumination for any feature **120** of the vehicle **28** or the trailer **32**, and/or a warning indicator.

As described above, the energy conversion layer **16** of the photoluminescent structure **10** may include at least one photoluminescent material having energy converting elements with phosphorescent or fluorescent properties. For example, the photoluminescent material may include organic or inorganic fluorescent dyes including rylenes, xanthenes, porphyrins, phthalocyanines. Additionally, or alternatively, the photoluminescent material may include phosphors from the group of Ce-doped garnets such as YAG:Ce.

As illustrated in FIG. **9**, the target assembly **26** may be attached, coupled, and/or over molded to a vertical surface **116** of the trailer **32**. According to one embodiment, the target assembly **26** is flushly mounted to the trailer **32** thereby partially concealing from view in the unilluminated state. Additionally, the lighting system **22** and/or one or more components thereof have a soft conformable encapsulation layer to both protect the lighting system **22** and to limit flexing of portions of the lighting system **22**. Exemplary materials that may be utilized include, but are not limited to, polyvinyl chloride, vulcanized thermoplastic elastomer, and polyester elastomer.

As discussed above, the target assembly **26** may include a viewable portion **124** that is arranged over the photoluminescent structure **10**, and may be formed by the encapsulation layer. In some embodiments, the viewable portion **124** may include a plastic, silicon, or urethane material and is molded over the photoluminescent structure **10** and/or any other component of the target assembly. Preferably, the viewable portion **124** should be at least partially light transmissible. In this manner, the viewable portion **124** will be illuminated by the photoluminescent structure **10** whenever an energy conversion process is underway. Additionally, by over-sealing the viewable portion **124**, it may also function to protect the photoluminescent structure **10** and or any other components of the target assembly **26**. The viewable portion **124** may be arranged in a planar shape and/or an arcuate shape to enhance its viewing potential when in a luminescent state.

With respect to the presently illustrated embodiment, the excitation of photoluminescent materials may be mutually exclusive. That is, the first and second photoluminescent materials are formulated to have non-overlapping absorption spectrums and Stoke shifts that yield different emission spectrums. Also, in formulating the photoluminescent materials, care should be taken in choosing the associated Stoke shifts such that the converted light **88** emitted from one of the photoluminescent materials, does not excite the other, unless so desired. According to one exemplary embodiment, a first portion of the light source **82** is configured to emit an inputted light **86** having an emission wavelength that only excites the first photoluminescent material and results in the inputted light **86** being converted into a visible light **88** of a first color (e.g., white). Likewise, a second portion of the light source **82**, is configured to emit an inputted light **86**

having an emission wavelength that only excites second photoluminescent material and results in the inputted light **86** being converted into a visible light **88** of a second color (e.g., red). The first and second colors may be visually distinguishable from one another. In this manner, the light source **82** may be selectively activated using a controller **128** to cause the photoluminescent structure **10** to luminesce in a variety of colors. For example, the controller **128** may activate the light source **82** to exclusively excite the first photoluminescent material, resulting in the viewable portion **124** illuminating in the first color. Alternatively, the controller **128** may activate the light source **82** to exclusively excite the second photoluminescent material, resulting in the viewable portion **124** illuminating in the second color.

Alternatively still, the controller **128** may activate the light source **82** to cause both of the photoluminescent materials to become excited, resulting in the viewable portion **124** illuminating in a third color, which is a color mixture of the first and second color (e.g., pinkish). The intensities of the inputted light **86** emitted from the light source **82** may also be proportionally varied by wavelength to one another such that additional colors may be obtained. For energy conversion layers **16** containing more than two distinct photoluminescent materials, a greater diversity of colors may be achieved. Contemplated colors include red, green, blue, and combinations thereof, including white, all of which may be achieved by selecting the appropriate photoluminescent materials and correctly manipulating the corresponding light source **82**.

Referring to FIG. **10**, a lighting system **22** is shown, according to one embodiment, and is intended for use with the trailer backup assist system **30**. The lighting system **22** includes a camera **50** having an image sensor **126** that captures light and converts it into image data. The camera **50** can be mounted to the rear of a tow vehicle **28** and positioned to image a target assembly **26** located on a trailer **32** that is attached to the vehicle **28**. The target assembly **26** may be configured in a rectangular configuration having a checker pattern that is recognizable by the camera **50**. In one embodiment, the checker pattern may incorporate a plurality of photoluminescent structures having varying photoluminescent materials therein such that the photoluminescent structures illuminate in a first color and a second color that is different than the first color, as described above.

The lighting system **22** further includes a controller **128** that may be integrated with the camera **50** or located external thereto. The controller **128** can include circuitry such as a processor **130** and memory **132**. A routine **134** for adjusting an image capture setting can be stored in the memory **132** and is executed by the processor **130**. In one embodiment, the controller **128** is configured to set a reference point corresponding to an area of the target assembly **26** or trailer **32** that has a known color and a known intensity. By knowing how the reference point should appear in a captured image, the controller **128** can analyze image data received from the camera **50** and adjust the white balance and exposure of the camera **50** to compensate for changing light conditions such as when the vehicle **28** and trailer **32** move from a sunny area to a shaded area. Alternatively, the target assembly **26** and light source **82** may vary in lighting intensity to compensate for environmental factors thereby providing a uniform intensity of emitted light **86**, **88** from the target assembly **26**.

With respect to the illustrated embodiment, the controller **128** can also communicate with a positioning device **136**, shown as a GPS enabled device to receive input related to the geographical location of the vehicle **28** and trailer **32**. The GPS enabled device can be any suitable device capable of communicating with the controller **128**. In one embodiment, the GPS enabled device is an onboard device such as, but not limited to, a Human Machine Interface (HMI). In another embodiment, the GPS enabled device is a portable electronic device such as, but not limited to, a portable GPS device or a GPS enabled smart device, both capable of wirelessly communicating with the controller **128** via Bluetooth®, Wi-Fi, the like, or a combination thereof. Since light conditions may vary depending on one's geographical location, the controller **128** can give consideration to the locational input supplied by the GPS enabled device in deciding whether an adjustment to the camera **50** and/or intensity of light emitting from the light source **82** is needed.

Since light conditions may also vary depending on the current time, date, and weather conditions, the controller **128** can additionally receive time and date information via input **138** and weather information via input **140**, which may either or both be considered by the controller **128** in deciding whether an adjustment to the light source **82** is needed. For example, the light intensity in Florida during a clear summer afternoon will generally be higher than the light intensity in Michigan during an overcast summer morning. Thus, by making this type of information known to the controller **128**, the controller **128** can predict certain characteristics related to the light captured by the image sensor **188** of the camera **50** and adjust the image capture settings of the camera **50** and/or light source **82** accordingly. Per the previously given example, if a vehicle **28** and trailer **32** are located in Florida, the controller **128** may choose to decrease the intensity of light emitted from the light source **82** whereas the controller **128** may choose to increase the intensity of light emitted from the light source **82** if the vehicle **28** and trailer **32** are located in Michigan. It is contemplated that the controller **128** can receive the time and date information via the GPS enabled device, a portable electronic device, the electronic control module (ECM) of the vehicle **28**, or any other suitable means. The weather information may be supplied to the controller **128** via an application running on a portable electronic device or an onboard device (e.g. HMI), or any other suitable means.

In addition to the abovementioned inputs **198**, **200**, the controller **128** may receive input from one or more equipment **142** located on the vehicle **28** and/or the trailer **32**, which includes, but is not limited to, light sensors, speed sensors, inertia sensors, directional compasses, and/or other cameras **50**, which can be provided in front, rear, and side facing configurations. By leveraging some or all of the equipment **142** with other devices and inputs described previously, the controller **128** can determine the orientation of the vehicle **28** and the trailer **32** relative to a light source **82**, such as the sun.

According to one embodiment, the lighting system **22** is configured to compensate for changing light conditions caused when the rear vehicle lights of the vehicle **28** are activated. The rear lights may include taillights, brake lights, supplemental lights, and other forms of rear lighting. When activated, the rear lights may project light upon the imaged scene, thereby causing a sudden change in lighting conditions. If unaccounted for, the lighting system **22** may experience difficulty tracking the target assembly **26**, thus the light source **82** intensity may adjust to compensate for such conditions.

According to one embodiment, the controller **128** may also provide electrical power to the lighting system **22** via a power source **144** located onboard the vehicle **28**. In addition, the controller **128** may be configured to control the

inputted light emitted from each light source **82** based on feedback received from one or more vehicle control modules **146** such as, but not limited to, a body control module, engine control module, steering control module, brake control module **72**, the like, or a combination thereof. By controlling the inputted light **86** emitted from the light source **82**, the lighting system **22** may illuminate in a variety of colors and/or patterns to provide an aesthetic appearance, or may provide vehicle information to an intended observer. For example, when the lighting system **22** is illuminated, the lighting system **22** may notify an occupant of the vehicle **28** about a specific condition of the vehicle **28**. It should be appreciated, however, that the target assembly **26** may include an independent controller **128** therein for implementing the functions described herein.

In operation, the photoluminescent structure **10** may exhibit periodic unicolor or multicolor illumination. For example, the controller **128** may prompt the light source **82** to periodically emit only the first wavelength of inputted light **86** via the light source **82** to cause the photoluminescent structure **10** to periodically illuminate in the first color. Alternatively, the controller **128** may prompt the light source **82** to periodically emit only the second wavelength of inputted light **86** via light source **82** to cause the photoluminescent portion to periodically illuminate in the second color. Alternatively, the controller **128** may prompt the light source **82** to simultaneously and periodically emit the first and second wavelengths of inputted light **86** to cause the photoluminescent structure **10** to periodically illuminate in a third color defined by an additive light mixture of the first and second colors. Alternatively still, the controller **128** may prompt the light source **82** to alternate between periodically emitting the first and second wavelengths of inputted light **86** to cause the photoluminescent structure **10** to periodically illuminate by alternating between the first and second colors. The controller **128** may prompt the light source **82** to periodically emit the first and/or second wavelengths of inputted light **86** at a regular time interval and/or an irregular time interval.

In another embodiment, the lighting system **22** may include a user interface **84**. The user interface **84** may be configured such that a user may control the wavelength of inputted light **86** that is emitted by the light source **82**. Such a configuration may allow a user to control which features **178** (FIG. **7**) are illuminated.

With respect to the above examples, the controller **128** may modify the intensity of the emitted first and second wavelengths of inputted light **86** by pulse-width modulation or current control. In some embodiments, the controller **128** may be configured to adjust a color of the emitted light by sending control signals to adjust an intensity or energy output level of the light source **82**. For example, if the light source **82** is configured to emit the inputted light at a low level, substantially all of the inputted light may be converted to the outputted light. In this configuration, a color of light corresponding to the outputted light may correspond to the color of the emitted, outputted light from the lighting system **22**. If the light source **82** is configured to output the inputted light at a high level, only a portion of the inputted light may be converted to the outputted light. In this configuration, a color of light corresponding to mixture of the inputted light and the outputted light may be output as the emitted light. In this way, each of the controllers **128** may control an output color of the emitted light.

Though a low level and a high level of intensity are discussed in reference to the inputted light of inputted light **86**, it shall be understood that the intensity of the inputted light may be varied among a variety of intensity levels to adjust a hue of the color corresponding to the emitted light from the lighting system **22**. The variance in intensity may be manually altered or automatically varied by the controller **128** based on pre-defined conditions. According to one embodiment, a first intensity may be output from the lighting system **22** when a light sensor senses daylight conditions. A second intensity may be output from the lighting system **22** when the light sensor determines the vehicle **28** is operating in a low light environment.

As described herein, the color of the outputted light **88** may be significantly dependent on the particular photoluminescent materials utilized in the photoluminescent structure **10**. Additionally, a conversion capacity of the photoluminescent structure **10** may be significantly dependent on a concentration of the photoluminescent material utilized in the photoluminescent structure **10**. By adjusting the range of intensities that may be output from the light source **82**, the concentration, types, and proportions of the photoluminescent materials in the photoluminescent structure **10** discussed herein may be operable to generate a range of color hues of the emitted light by blending the first, inputted light **86** with the second, outputted **88** wavelength.

Accordingly, a lighting system configured as a trailer hitch angle detection component that cooperates with a vehicle is configured to illuminate an area and/or in a pre-defined pattern for recognition by the vehicle has been advantageously provided herein. The lighting system retains its structural properties while providing luminescent light having both functional and decorative characteristics.

It will be understood by one having ordinary skill in the art that construction of the described invention and other components is not limited to any specific material. Other exemplary embodiments of the invention disclosed herein may be formed from a wide variety of materials, unless described otherwise herein.

For purposes of this disclosure, the term "coupled" (in all of its forms, couple, coupling, coupled, etc.) generally means the joining of two components (electrical or mechanical) directly or indirectly to one another. Such joining may be stationary in nature or movable in nature. Such joining may be achieved with the two components (electrical or mechanical) and any additional intermediate members being integrally formed as a single unitary body with one another or with the two components. Such joining may be permanent in nature or may be removable or releasable in nature unless otherwise stated.

It is also important to note that the construction and arrangement of the elements of the invention as shown in the exemplary embodiments is illustrative only. Although only a few embodiments of the present innovations have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited. For example, elements shown as integrally formed may be constructed of multiple parts or elements shown as multiple parts may be integrally formed, the operation of the interfaces may be reversed or otherwise varied, the length or width of the structures and/or members or connector or other elements of the system may be varied, the nature or number of adjustment positions provided between the elements may be varied. It should be noted that the elements and/or assemblies of the system may be con-

structed from any of a wide variety of materials that provide sufficient strength or durability, in any of a wide variety of colors, textures, and combinations. Accordingly, all such modifications are intended to be included within the scope of the present innovations. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions, and arrangement of the desired and other exemplary embodiments without departing from the spirit of the present innovations.

It will be understood that any described processes or steps within described processes may be combined with other disclosed processes or steps to form structures within the scope of the present invention. The exemplary structures and processes disclosed herein are for illustrative purposes and are not to be construed as limiting.

It is also to be understood that variations and modifications can be made on the aforementioned structures and methods without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

1. A lighting system for a trailer towed by a vehicle, comprising:

a hitch angle detection component disposed on the trailer having a predetermined image pattern provided for capture by an imaging device and recognition by an image processing unit;

a light source disposed on the vehicle; and

a photoluminescent structure forming the image pattern through a plurality of portions having the photoluminescent structure therein on the detection component and configured to luminesce in response to excitation by the light source.

2. The lighting system for a trailer of claim **1**, wherein the hitch angle detection component includes a predetermined image pattern of a certain size and shape.

3. The lighting system for a trailer of claim **2**, wherein the photoluminescent structure comprises at least one photoluminescent material configured to down convert an inputted light received from at least a portion of the light source into a visible light that is outputted to a viewable portion.

4. The lighting system for a trailer of claim **3**, wherein the inputted light comprises one of blue light, violet light, and UV light.

5. The lighting system for a trailer of claim **1**, wherein the hitch angle detection component is configured as a target.

6. The lighting system for a trailer of claim **5**, wherein the target cooperates with a trailer backup assist function of a vehicle.

7. The lighting system for a trailer of claim **1**, wherein the light source is configured to vary an intensity of inputted light based on environmental characteristics of the detection component.

8. A lighting system for a trailer, comprising:

a light source on a vehicle;

a target assembly on a trailer having a first luminescent structure thereon and configured to luminesce in response to excitation by the light source; and

an imaging device, wherein the light source is configured to emit varied intensities of inputted light based on environmental characteristics such that the imaging device captures a redefined intensity of luminescence from the first luminescent structure.

9. The lighting system of claim **8**, wherein target assembly includes a predetermined image pattern of a certain size and shape provided through a surface thereof for capture by an imaging device and recognition by an image processing unit.

10. The lighting system of claim **8**, wherein the light source emits inputted light in the blue spectrum and the first luminescent structure converts the inputted light to outputted light of a different wavelength.

11. The lighting system of claim **8**, further comprising:

a second luminescent structure disposed on a feature proximate to the light source.

12. The lighting system of claim **11**, wherein the first luminescent structure illuminates in a first color and the second luminescent structure illuminates in a second color.

13. The lighting system of claim **11**, wherein the first and second luminescent structures are disposed in a checkered pattern on the target assembly.

14. The lighting system of claim **8**, wherein the light source emits inputted light rearwardly of the vehicle as the vehicle moves forwardly.

15. A lighting system for a trailer assembly having a trailer towed by a vehicle, comprising:

a hitch angle detection component located on the trailer;

a light source powered by the vehicle and configured to emit non-visible light while the vehicle is moving in a forward direction; and

a photoluminescent structure disposed on the detection component and configured to luminesce in response to excitation by light output from the light source.

16. The lighting system for a trailer assembly of claim **15**, further comprising:

an imaging device capturing images of the detection component.

17. The lighting system for a trailer assembly of claim **16**, wherein the pattern is captured by the imaging device and recognized by an image processing unit.

18. The lighting system for a trailer assembly of claim **15**, further comprising:

a controller configured to control the inputted light emitted from the light source.

19. The lighting system for a trailer assembly of claim **18**, further comprising:

a sensor configured to monitor an intensity of outputted light emitted from the photoluminescent structure, wherein the controller varies the intensity of light emitted from the light source based on the intensity of measured outputted light.

20. The lighting system for a trailer assembly of claim **15**, wherein the light source is illuminated when a vehicle transmission is placed in reverse and returns to an unilluminated state when the vehicle is removed from a reverse position.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,464,886 B2
APPLICATION NO. : 14/820999
DATED : October 11, 2016
INVENTOR(S) : Salter et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 18:

Claim 8, Line 4:

"redefined" should be --predefined--.

Signed and Sealed this
Third Day of January, 2017

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office